# Gaseous Emissions Calculations

1. Method 6C bias/drift correction for gaseous emissions ($O_2$, $CO_2$, $SO_2$, $NO_x$ and CO):

$$C_{gas} = (C_{raw} - C_o) \times \frac{C_{ma}}{C_m - C_o}$$

where:
- $C_{gas}$ = Effluent gas concentration, dry basis, ppm or %.
- $C_{raw}$ = Average gas concentration indicated by gas analyzer, dry basis, ppm or %
- $C_o$ = Average of initial and final system calibration bias check responses for the zero gas, ppm or %.
- $C_{ma}$ = Actual concentration of the upscale calibration gas, ppm or %.
- $C_m$ = Average of initial and final system calibration bias check responses for the upscale calibration gas, ppm or %.

2. Parts per million corrected to 8% oxygen (ppm@8%$O_2$):

$$ppm@8\%O_2 = C_{gas} \times \frac{20.9 - 8\%}{20.9 - \%O_2}$$

3. Pound per hour (lb/hr) calculation based on EPA Method 2 flowrate for emissions of $SO_2$, $NO_x$ and CO:

$$lb/hr = C_{gas} \times MW \times dscfm \times Const.$$

where:
- lb/hr = Emissions expressed as pounds per hour.
- $C_{gas}$ = Effluent gas concentration, dry basis, ppm.
- MW = Molecular weight: $SO_2$ = 64, $NO_x$ = 46.1, CO = 28.
- dscfm = gas flowrate, dry standard cubic feet per minute.
- Const. = 1.557E-7, derived below:

$$1.557E-7 = \frac{1\,mole}{24.06\,L}\,x\,\frac{1\,\text{lb}}{453.6\,g}\,x\,\frac{0.02832\,cu.m}{1\,\text{cu.ft.}}\,x\,\frac{60\,\text{min}}{1\,\text{hr}}\,x\,\frac{1\,\text{L}}{1{,}000\,\text{ml}}$$

**4.** Pound per hour (lb/hr) calculation based on EPA Method 2 flowrate for emissions of Total Hydrocarbons (THC):

$$lb/hr = C_{gas} \times MW \times scfm \times Const.$$

where: $C_{gas}$ = Effluent gas concentration, wet basis, ppm.
MW = Molecular weight: C = 12
scfm = gas flowrate, standard cubic feet per minute.
Const. = 1.557E-7 (same as above).

**5.** Pound per hour calculation based on heat input (i.e. gas turbines):

$$lb/hr = \frac{lb}{MMBtu} \times \frac{MMBtu}{hr}$$

where: $\frac{lb}{MMBtu}$ = Gaseous emissions calculated below.

$\frac{MMBtu}{hr}$ = Heat input (provided by facility).

**6.** Pound per million British thermal unit:

$$\frac{lb}{MMBtu} = C_{gas} \text{ x MW x } F_d \text{ x } 2.59E-9 \text{ x } \frac{20.9}{20.9 - \%O_2}$$

where: $C_{gas}$ = Effluent gas concentration, dry basis, ppm.
MW = Molecular weight.
$F_d$ = Fuel factor as presented in 40CFR60, Method 19, Table 19-1.

**$NO_x$:**

$$NO_x\ (\text{g/HP - hr}) = \frac{(C_d)\times(1.912\times10^{-3})\times(Q)\times(T)}{(\text{HP - hr})}$$

Where:

| | | | |
|---|---|---|---|
| | $C_d$ | = | Measured $NO_x$ concentration in ppmdv |
| | $1.912 \times 10^{-3}$ | = | Conversion constant for ppm $NO_x$ to g/dscm @ 20° C |
| | Q | = | Stack gas flow rate in dscm/hr |
| | T | = | Time of test run in hours |
| | HP-hr | = | Brake work of the engine, provided by facility |

**CO:**

$$CO\ (\text{g/HP - hr}) = \frac{(C_d)\times(1.164\times10^{-3})\times(Q)\times(T)}{(\text{HP - hr})}$$

Where:

| | | | |
|---|---|---|---|
| | $C_d$ | = | Measured $NO_x$ concentration in ppmdv |
| | $1.164 \times 10^{-3}$ | = | Conversion constant for ppm CO to g/dscm @ 20° C |
| | Q | = | Stack gas flow rate in dscm/hr |
| | T | = | Time of test run in hours |
| | HP-hr | = | Brake work of the engine, provided by facility |

## EXHAUST GAS EMISSIONS CALCULATIONS

The following equations will be used in calculating flow rates, pollutant concentrations and emission rates, and oxygen corrections. Generally, all flow rates used in the calculations will be dry standard volumetric rates and the conversion factors are standard scientific constants for mass, volume, temperature, and pressure conversions.

### Volume of Dry Gas Sampled at Standard Conditions

Volume of dry gas sampled at standard conditions, dscf [a]

$$\text{dscf}^{a} = \frac{528 \times (Y) \times (VM) \times (PB + PM)}{29.92 \times (TM + 460)}$$

where:

| | | |
|---|---|---|
| a | = | Dry standard cubic feet at 68°F (528°R) and 29.92 inches of Hg |
| Y | = | Dry gas meter calibration factor |
| VM | = | Sample gas Volume, $ft^3$ |
| PB | = | Barometric Pressure |
| PM | = | Average Orifice Pressure Drop, inches of Hg |
| TM | = | Average Dry Gas Temperature at meter, °F |

### Velocity of the Exhaust Gas

Stack gas velocity at stack conditions, afpm

$$\text{afpm} = 5130^{b} \times Cp \times SDE_{avg} \times [1 / (PS \times MW)]^{1/2}$$

where:

| | | |
|---|---|---|
| b | = | $5130 = 85.5\ \text{ft/sec}\ \left[\frac{(\text{lb/lb-mole}) \times (\text{in. Hg})}{(°R) \times (\text{in. } H_2O)}\right] \times 60\ \text{sec/min}$ |
| Cp | = | Pitot tube coefficient |
| $SDE_{avg}$ | = | $(P\ )^{1/2}{}_{avg} \times (\text{Stack Temp}_{avg})^{1/2} + 460$ |
| PS | = | Stack Pressure, absolute<br>inches of Hg = Barometric Pressure ± Avg Stack Static Pressure |
| MS | = | Molecular Weight of Wet Stack Gas |

**Volumetric Flow Rate of the Exhaust Gas**

Stack gas volumetric flow rate at standard conditions, $dscfm^c$

$$dscfm^c = \frac{acfm \times 528 \times MD \times PS}{(29.92) \times (TS_{avg} + 460)}$$

where:

| | | |
|---|---|---|
| c | = | Dry standard cubic feet per minute at 68°F (528°R) and 29.92 in.Hg |
| MD | = | Mole Fraction of Dry Gas (dimensionless) |
| PS | = | Stack Pressure, absolute, inches of Hg |
| $TS_{avg}$ | = | Average Stack Temperature |

## PM EMISSIONS

### Particulate Matter - Grains Per Dry Standard Cubic Foot

Rates in terms of grains per dry standard cubic feet (gr/dscf) will be calculated using the pollutant rate in terms of milligrams (mg) divided by the volume of gas collected (dscf).

$$gr/dscf = 0.0154 \times mg \div \left[ \left\{ \frac{528 \times (Y) \times (VM) \times (PB + PM)}{29.92 \times (TM + 460)} \right\} \right]$$

where:

| | | |
|---|---|---|
| dscf | = | Dry standard cubic feet at 68°F (528°R) and 29.92 inches Hg |
| 0.0154 | = | 0.0154 grains per milligram |
| Y | = | Dry gas meter calibration factor |
| VM | = | Volume metered, $ft^3$ |
| PB | = | Barometric Pressure, inches Hg |
| PM | = | Average Orifice Pressure Drop, inches Hg (Avg. $\Delta H$ inches $H_2O \div 13.6$) |
| TM | = | Average Dry Gas Temperature at Meter, °F |

### Particulate Matter - Grains Per Dry Standard Cubic Foot Corrected to 7% Oxygen

Concentrations in gr/dscf will be corrected to 7% oxygen using the following equation:

$$gr/dscf\ @\ 7\%\ O_2 = gr/dscf \times \frac{(20.9 - 7)}{(20.9 - \%O_{2\ measured})}$$

### Particulate Matter - Pounds Per Hour

Rates in terms of pounds per hour (lbs/hr) will be calculated using the particulate matter rate in terms of grains per dry standard cubic feet (gr/dscf), flowrate - dscfm (Qs), 60 minutes/ hour, divided by 7,000 grains per pound (gr/lb).

$$lbs/hr = \frac{gr/dscf \times Qs \times 60}{7000}$$

### Particulate Matter - Pounds Per Million BTU

Rates in terms of pounds per million (lbs/mmBtu) will be calculated using the particulate matter rate in terms of grains per dry standard cubic feet (gr/dscf), f-factor (dscf/mmBtu), and oxygen (%).

$$lbs/mmBtu = gr/dscf \times F \times 0.0001429 \times \frac{20.9}{(20.9 - \%O2)}$$